USGS
science for a changing world

Strategic Science Plan

December 30, 2005

U.S. Geological Survey
Forest and Rangeland Ecosystem Science Center
Science
777 NW 9th Street
Corvallis, Oregon 97330

Table of Contents

Strategic Plan for the USGS Forest and Rangeland Ecosystem Science Center Science Program

Natural Science in the West

The western United States contains some of the most remote, pristine landscapes in the Nation, with a rich biodiversity of species and habitats. Technological advances, human demographic growth, and competing demands for resources are leading to rapid changes in the West, and nearly all natural areas face a variety of stresses. The Pacific Northwest, in particular, faces a number of critical resource management issues, including changes in fire cycles, expansion of invasive species, degradation and loss of habitat, and declines of native species and habitats. Land managers are faced with increasing demands to provide for economic benefits (e.g., timber harvest, grazing, recreational use) while at the same time preserving and protecting natural resources in a sustainable manner. Additionally, our understanding of the interconnected nature of many natural science issues is growing, leading to the need to evaluate science issues at multiple scales to understand the effects of natural and anthropogenic changes. There is a greater need for scientific information to make informed management decisions, and to predict and monitor outcomes of decisions. To meet current and emerging science needs, the USGS Forest and Rangeland Ecosystem Science Center (FRESC) must build on its traditional strengths while growing in terms of capability, flexibility, and responsiveness.

Using this strategic plan for science, FRESC is working to conduct socially relevant and high-quality natural science primarily, but not exclusively, in the Pacific Northwest and Intermountain West. We also strive to use information technology to deliver information to support the needs of decision-makers and incorporate in our science an understanding of the needs of our many customers and partners. We acknowledge that strategic planning asks questions of the future and that no one can accurately predict the future. Nonetheless, we have done our best to anticipate what our world will look like, how FRESC will need to perform to succeed in the future, and what critical capabilities will prepare us for the changes to come.

Implementation of this plan will proceed from 2006 to 2011. It is the first strategic plan for FRESC's science program and builds on an implementation plan released in 1997 and a Center review conducted in 2005. The plan incorporates our best thinking about strategies, goals, and objectives for FRESC's science, as well as customer and partner feedback received through a consultation process. We recognize in proposing this plan that science is a long-term, cumulative process of posing questions, performing experiments, making observations, and acknowledgement and acceptance of science findings by peers. Some topics we address with this plan require research well beyond a five-year period, and although we plan to make significant progress in advancing understanding of these topics, we will not exhaust opportunities for

additional research. This strategic plan should be viewed as a living document, with the flexibility to meet changing information needs and new science priorities, and to serve as a guide to direct research programs beyond the next five years.

Organizational Context

The organizational context for FRESC's science has three major dimensions – the Center's history, the variety of public and private organizations that depend on us for science, and the strategic direction defined by the Department of the Interior (DOI) and the U.S. Geological Survey (USGS).

History

As an organizational unit of the federal government, FRESC is ten years old, but some of the groups that formed the Center started over 30 years ago. The mergers to form the Center and the eventual incorporation into the USGS were part of a series of reorganizations to the research capability of DOI that took place from 1993 to 1996. In the middle of these transitions, four federal research groups merged and adopted the Center's name. The founding groups were research staff from the Bureau of Land Management (BLM), the National Park Service (NPS), and the Fish and Wildlife Service (FWS), located in the states of Washington, Oregon, Idaho, Utah, and Arizona. In 2003, the USGS established the Southwest Biological Science Center, FRESC employees in Arizona and Utah were administratively transferred to that Center, and correspondingly, FRESC's geographic focus for research became primarily, but not exclusively, the states of Washington, Oregon, and Idaho.

From 1994 until 1995, FRESC's mission was to provide scientific understanding and the technology needed to support sound management and conservation of our Nation's natural resources, with emphasis on western ecosystems. The Center balanced the immediate need for information to guide management of biological resources with the need for technical assistance and long-range, strategic information to understand and predict emerging patterns and trends in living systems. We defined ten areas of core science capability: aquatic and wetland ecosystems, arid and semiarid ecosystems, contaminants and anthropogenic pollution, forest ecosystems, human dimensions of resource management, invasive species, landscape dynamics and resource management, population viability and conservation genetics, restoration ecology, and wildlife ecology. These categories reflected the array of scientific capability that merged to form the Center. Primary customers and partners were the BLM, NPS, and FWS. A distinctive feature of FRESC was a relatively small staff of researchers with capability in the core science areas who worked closely with universities and other research institutions to expand the breadth of science capability and conduct a diverse program of affordable, quality science.

Department of the Interior

The USGS is one of eight bureaus in the DOI. The DOI mission is to protect and manage the Nation's natural resources and cultural heritage; provide scientific and other information about those resources; and honor its trust responsibilities or special commitments to American

Indians, Alaska Natives, and affiliated island communities. The DOI has subdivided that mission into four key areas of responsibility: resource protection, resource use, recreation, and serving communities. There are science needs associated with all of these areas, but the DOI relies particularly on natural science to achieve resource-protection and resource-use goals.

U.S. Geological Survey

The USGS, established in 1879, is the DOI's and the Nation's principal natural science and information agency. The USGS conducts research, monitoring, and assessments to contribute to understanding the natural world — America's lands, water, and biological resources. The USGS provides reliable, impartial information in the form of maps, data, and reports containing analyses and interpretations of water, energy, mineral and biological resources, land surfaces, marine environments, geologic structures, natural hazards, and dynamic processes of the Earth. The USGS vision, mission, and strategic direction focus on responsiveness and customer service, underscoring the application of science to customer, partner, and other stakeholder needs. They direct the combined expertise of four scientific disciplines, Geography, Geology, Water, and Biology, and define the bureau's commitment to pursuing an integrated approach to providing science. The Biological Resources Discipline (BRD), which includes FRESC, carries out research and develops technologies for organizations concerned with living resources. Department of Interior bureaus – especially the FWS, BLM, NPS, and Bureau of Reclamation (BOR) are foremost among the DOI agencies that BRD supports.

FRESC Mission

FRESC's mission is to provide scientific understanding and technology needed to support sound management and conservation of our nation's natural resources, with an emphasis on western ecosystems. Our vision is that natural resource managers, policy makers, and the scientific community will recognize FRESC as a premier source of unbiased and socially relevant scientific information. To achieve this vision, FRESC will maintain a highly flexible and adaptive infrastructure so that it can be responsive and effective in anticipating and addressing emerging issues in natural resource conservation and management. FRESC will continue its emphasis on conducting cost-effective and highly competitive interdisciplinary, team-oriented research. Much of FRESC's research program focuses on 1) issues that require long-term attention, 2) applied resource issues driven by federal, state, and local agency mandates, and 3) basic research focused on understanding ecological systems and developing new concepts that will build scientific foundations. A priority for FRESC is to conduct and provide scientific research and information to land and resource managers that will support informed decision-making. To help achieve this goal, FRESC will continue a significant investment in production of easy-to-use scientific information delivery systems that synthesize and convey complex scientific information for decision-makers and the public. Eight guiding principles define the practices we strive to incorporate in our science programs (Table 1).

Partnerships and Collaborations

Much of FRESC's work is conducted in collaboration with DOI bureaus, other government agencies and tribes, universities, other USGS science centers, and non-governmental organizations. Partnerships and collaboration range from professional relationships among individual scientists to formal institutional arrangements and agreements between agencies. These relationships are used to identify research needs, facilitate and conduct research, or communicate science findings and possible applications. Successful accomplishment of FRESC's mission depends on close collaborations with DOI bureaus to identify research priorities, to ensure that high-priority questions are being addressed, and to produce research products that meet the customer's needs. Because of FRESC's history and the resource demands in the Pacific Northwest, one of the Center's highest priorities is to address the research and information needs of NPS, BLM, and FWS. Research needs of these agencies center on resource and land management, and resource conservation and protection.

Table 1. Guiding principles for FRESC science.

° Be a leading provider of ecological science and expertise to resource managers and decision-makers, with emphasis on agencies within the DOI
° Provide scientific information to support conservation of biological resources, particularly as they relate to the trust responsibilities and agency needs of the Department of the Interior and the Nation
° Maintain a balance of short-term research to address rapidly emerging issues and long-term research required for resource management and planning
° Develop and test tools and techniques for managing and assessing natural resources
° Address issues associated with aquatic and terrestrial ecosystems at multiple spatial and temporal scales
° Strengthen our understanding of human impacts (e.g., invasive species, pollutants, commodity production, global change, etc.) on natural processes, and provide scientific foundation for restoration and mitigation programs
° Provide scientific leadership in support of conservation of species and habitats that are at risk of extirpation or extinction
° Provide scientists, resource managers, policy makers and the general public with efficient and timely access to scientific information in a way that is understandable to them
° Deliver high quality, unbiased scientific information based on peer review

Partnerships with universities are used by FRESC to extend the Center's science capabilities and provide excellent science in a cost-effective way. Three of FRESC's research

groups are located on major university campuses, where Center scientists maintain affiliate or courtesy status, participate on graduate committees, and collaborate in conducting research. The Center also is a member of two Cooperative Ecosystem Studies Units, one with a focus on the Pacific Northwest and the other the Great Basin. Universities are the business managers of these units, and in special cases these units can be used to collaborate with universities, and even with other agency partners.

The need for interdisciplinary collaboration is increasingly important as we are called upon to provide understanding of complex natural systems. The issues our partners often face require a holistic, interdisciplinary approach to meet their needs, and FRESC scientists and managers routinely interact with other disciplines within the USGS when needed to address complex issues.

Science Plan Goals and Objectives

Over the next five years we will focus our research in five science themes: ecosystem ecology, landscape ecology, restoration and management of ecological systems, conservation biology, and status and trends. These themes are interrelated and any particular piece of science may overlap several themes. Although this plan provides strategic direction for the next five years, clearly most of the research topics will span a much greater time frame than the lifespan of this plan.

Ecosystem Ecology

Ecosystem ecology is the study of the interactions among organisms and their environment as an integrated system. Life is diverse, from bacteria and fungi to plants and animals, and all living organisms possess a characteristic relationship to their environment. Consequently, it is impractical to study each and every organism-environment interaction for an entire ecosystem at one time. To address this difficulty, ecosystem ecology focuses on understanding the factors that control aggregate or emergent properties of organism-environment interactions. Emergent properties such as ecosystem structure, productivity, nutrient cycling, and energy balance form the currency of ecosystem ecology. In a simple sense, unique combinations of emergent properties can form the basis for how we distinguish different ecosystems like deserts, grasslands, wetlands, forests, streams, or lakes. Yet at the societal level, emergent properties of ecosystems also underlie the provision of many essential ecological goods and services of great importance, such as purification of air and water, fiber production, soil stabilization, and others. The discipline of ecosystem ecology is tightly linked to other research themes. For example, principles of ecosystem ecology are routinely employed when considering what factors influence success of invasive species and their reciprocal impacts on native ecosystems, the movement of contaminants through food chains, the potential and limitation for ecosystem restoration, and indicators and predictions of whole-ecosystem response to global change.

The following goals and objectives will guide research and technology developments in ecosystem ecology. We seek both the advancement of whole-ecosystem approaches to

understanding and management, and an ecosystem context for studies associated with other science themes.

Goal 1: Provide the foundation for understanding how key emergent properties of forest, rangeland, aquatic, and linked aquatic-terrestrial habitats vary throughout the Pacific Northwest and Intermountain West

- Expand our understanding of how geologic, atmospheric, and biological factors influence soil development, water quality, and the potential productivity of aquatic and terrestrial habitats
- Expand our understanding of climate's influence on the development of terrestrial, aquatic, and linked terrestrial-aquatic habitats, from rainforest to desert
- Improve our understanding of energy and materials transfers between land and water, and the biological communities that depend on these transfers
- Improve our understanding of whether and how biological diversity and keystone species influence whole-ecosystem emergent properties across a range of temporal and spatial scales

Goal 2: Promote development of ecosystem-scale tools and techniques to assess ecosystem response to management and global change

- Develop decision support tools to assess how common management activities (e.g., logging, grazing, water diversion and damming) affect sustainability of key ecosystem services
- Develop decision support tools to assess global change effects on provision of key ecosystem services
- Test whether manipulating abiotic factors can alter trajectories of ecosystem development, and accelerate restoration of degraded and invaded habitats

Goal 3: Identify how ecosystem ecology can provide an ecosystem context to resource and land management and conservation

- Improve use of emergent properties to define ecosystem condition, and the factors necessary to promote and assess restoration success
- Determine importance of ecosystem-level constraints on food and habitat needs of species of concern
- Identify integrative metrics for ecosystem-level assessments in inventory and monitoring efforts
- Understand local and regional constraints on the resistance and resilience of ecosystems to natural and anthropogenic disturbances
- Identify factors that influence trajectories of ecosystem development and change at the scale of entire landscapes

- Evaluate the effects of resource management actions on ecosystem condition and viability at multiple scales

Landscape Ecology

Spatial patterns on the landscape and the biological and physical processes that generate them are the principal focus of landscape ecology. From a human perspective, the study of landscapes provides a context for understanding and predicting the effects of land use on natural ecosystems at the scale of kilometers. Watersheds, forests, rangelands, roads, riparian corridors, and human settlements form spatial mosaics that influence and, in turn, are influenced by ecological processes such as vegetative succession, hydrologic cycling, and natural disturbances such as floods, fire, and landslides. In this sense, landscape ecology is the study of the reciprocal effects of spatial pattern on ecological processes. The concern with spatial dynamics and heterogeneity of organisms, materials, and energy distinguishes landscape ecology from other disciplines in ecology that deal primarily with temporal dynamics, such as population growth and evolutionary change, independent of spatial context.

Landscape ecology addresses basic questions about scaling in ecology and applies new mapping technologies, such as geographic information systems, remote sensing, and spatial analysis, to discover scales appropriate to different ecological phenomena. Landscape research bridges multiple theme areas and forms the nexus of interdisciplinary studies in habitat fragmentation, ecological scaling, spatially explicit landscape modeling, patch dynamics, biogeography, and biodiversity conservation.

The following goals and objectives will guide research and technology developments in landscape ecology for addressing resource management needs in the Pacific Northwest and the Intermountain West, and for supporting geospatial analysis associated with other FRESC science themes.

Goal 1: Evaluate broad-scale patterns of land use and land-cover change and determine their ecological consequences for species distribution and abundance

- Expand our understanding of the patterns and processes influencing the distribution of terrestrial and aquatic communities, species, populations, and life histories
- Develop and test landscape descriptors (e.g., vegetation, climate, landform, management history) as predictors of terrestrial and aquatic characteristics

Goal 2: Identify how natural and anthropogenic disturbance interact to influence ecological function

- Improve understanding of the effects of habitat fragmentation on biodiversity and ecological processes
- Develop an understanding of the cumulative effects of natural and human-caused disturbance regimes, including contaminant exposure, at multiple temporal and spatial scales, and weigh alternatives for future management

- Identify how watershed processes (e.g., stream flow, channel formation, and sedimentation) respond to extreme climate events and natural and human-caused disturbance

Goal 3: Develop and apply geospatial tools in GIS, remote sensing, and spatial analysis to support resource management and other key FRESC theme areas

- Compare and refine advanced geostatistical techniques for analysis, prediction, and integration of species distribution patterns in relation to physical and biological characteristics
- Develop spatially explicit models of species distribution and movement that are appropriate for evaluating alternative management scenarios at watershed scales
- Evaluate the utility and efficiency of spatially extensive (e.g., remote sensing and broad-scale surveys) versus temporally intensive (e.g., site-, stand, and plot-based sampling) resource assessment methods
- Expand the understanding and application of new digital technologies in ecology for collecting, processing, storing, and documenting large geospatial and temporal databases
- Manage web-based spatial and non-spatial data to provide the information needed by researchers, resource specialists, managers, and the public

Restoration and Management of Ecological Systems

One of the overarching goals of habitat management is to sustain the ecological integrity and physical resources that encompass an ecosystem. Land managers often manipulate ecosystems to provide habitats that maintain certain plants and animals. Sustainable management is accomplished if those habitats are part of an ecosystem that maintains the physical resources and allows adequate ecological processes to operate. When those conditions are met, an ecosystem can either resist disturbances and habitats are maintained or an ecosystem can weather them in a resilient fashion and habitats recover in a reasonable time. Research and technology development can provide the information and tools to assist land and resource managers in implementing the most effective actions based on the management objective.

All biological systems contend with a range of disturbances, which can be natural or human caused. Natural disturbances (e.g., wildfires, high-water-flow events, drought, grazing by native species, insect invasions) form a part of the dynamics within biological systems, increasing species adaptability and leading to small- and large-scale habitat changes. Disturbances also can be human induced, influenced, or perpetuated (e.g., land management, contaminants, change in fire regimes, invasion of exotic species) leading to local or landscape-scale changes in ecological systems. Some species of plants and animals may not be able to sustain populations when disturbances occur at abnormal intervals (e.g., infrequent or too frequent fires) leading to declines or loss of native species, habitat degradation, habitat fragmentation, habitat loss, and alterations in ecosystem structure. In these situations, ecological restoration, the process of assisting the recovery and management of ecological integrity, may be necessary. Understanding how changes in the frequency, intensity and extent of both natural and

human-caused disturbances can influence ecological systems will assist in restoring and managing these systems, and possibly prevent future disturbance threats.

The following goals and objectives will be used to guide research and technology developments to maintain and support management of functioning ecosystems where they occur, and restore ecological integrity whenever possible.

Goal 1: Provide the scientific foundation for the restoration and management of forest, rangeland, and aquatic ecosystems in the Pacific Northwest and Intermountain West

- Expand understanding of changes that occur to ecological processes when habitats become degraded or are exposed to natural and anthropogenic disturbances
- Expand understanding of the population biology, life history, and ecophysiological responses of important native and invasive species within our ecosystems
- Develop information on spatial and temporal extent of biotic invasions in aquatic and terrestrial ecosystems
- Improve understanding of factors and processes that contribute to ecosystem resistance and resilience to invasive species
- Improve understanding of the role that temporal and spatial scales of habitat degradation play on the recovery potential of degraded habitats and on invasive species establishment and spread
- Improve understanding of the effects of fire and fire-management practices on ecological systems, including consideration of the spatial and temporal scale of fires
- Assess the cause and effects of changing fire cycles (increase or decrease) and the associated effects on species and habitats
- Increase understanding of sources, fate, exposure and effects of environmental contaminants, including emerging contaminants, on organisms, populations, and communities
- Improve the scientific basis for evaluating the effects of multiple stressors at all levels of biological organization and at multiple temporal and spatial scales
- Increase understanding of the connection between physical and ecological processes to improve ecosystem restoration

Goal 2: Provide tools and techniques useful for effective science-based management of species and habitats, including their restoration

- Develop and test methods and technology to support species and habitat management and to monitor the effectiveness of management actions
- Develop and test methods, technology, and decision support tools to assist in the restoration of aquatic and terrestrial ecosystems
- Develop predictive models of the short- and long-term effects of wildland and prescribed fire on plants, animals and habitats

- Develop and test techniques for controlling invasive species and enhancing restoration of native species
- Develop scientific methods and tools to determine sources, fate, exposure and effects of environmental contaminants, including emerging contaminants

Goal 3: Evaluate management practices and develop alternative practices to assist in meeting resource management goals

- Expand understanding of the effects of management practices on the sustainability of ecological processes in terrestrial and aquatic habitats
- Provide the scientific information needed to understand options for control of invasions and rehabilitation and restoration of ecosystems
- Evaluate the effects and effectiveness of fuel-reduction treatments used by land managers
- Develop monitoring techniques to evaluate the effectiveness of post-fire stabilization and rehabilitation treatments
- Develop scientific basis for evaluating ecological effects, and for remediation of habitats and recovery of species affected by contaminants (e.g., mining, agriculture, urban wastewater, industrial development, and chemical-control agents)
- Design monitoring strategies and improve the efficiency of techniques to determine the effectiveness of restoration and management techniques
- Evaluate monitoring information to assess the effects of disturbances and management actions at multiple scales
- Use long-term data to assess the effects of anthropogenic and ecological processes on habitats and species, and develop a long-term monitoring strategy for key ecosystems

Goal 4: Identify factors that contribute to or limit the maintenance or recovery of ecological systems

- Improve our understanding of abiotic and biotic thresholds that may limit ecological recovery of habitats and species
- Evaluate how management strategies favor invasive species over native forms, and how to reverse any negative trends
- Evaluate how management practices may reduce or accentuate the effect of disturbances (e.g., control or expansion of invasive species, alteration of normal fire cycles)
- Determine the role that microbial communities play in the maintenance and recovery of habitats
- Identify impediments to effective restoration and management of ecological systems
- Identify and improve our understanding of landscape level changes (e.g., global climate change, long-term change in fire cycles) that may alter abilities to meet management goals

Conservation Biology

Conservation biology integrates multiple disciplines to provide the scientific basis for efforts to conserve, restore, and sustain biological diversity. This discipline has historical and modern-day connections to science efforts associated with land management, soil and water conservation, fish and wildlife management, and related disciplines. It has emerged over the last 30 years as a discipline of its own, largely because so many species are at risk, and those at risk go well beyond the vertebrates traditionally targeted in fish and wildlife management. In its broadest sense, conservation biology addresses all forms of life, including species, populations, and communities within ecosystems, as well as the ecological and evolutionary processes that influence these life forms. With such breadth, the discipline reaches out to include biological sciences like biology, zoology, botany, and ecology, as well as physical sciences, social sciences, and subjects such as law and education that determine how we implement conservation.

At FRESC, the focus of conservation biology research is at the level of species and populations. Research commonly involves understanding distribution, abundance, reproduction, diet, behavior, and movement characteristics of species or populations. Scientists are engaged in research designed to understand effects of natural and anthropogenic factors (e.g., habitat fragmentation, invasive species, climate change, contaminants, and management practices) on species and populations. Several biological measures, in correlation with physical characteristics, are used to understand the status and trends of species and to support effective conservation and management of species. Research in conservation biology is connected to other research areas to provide understanding of ecological systems at multiple scales.

The following goals and objectives will guide research and technology developments that support conservation and management of species, populations, and other forms of biodiversity.

Goal 1: Provide the scientific foundation to support the conservation and management of plant and wildlife populations and to maintain biodiversity

- Describe the life history, demographics, habitat requirements, behaviors, and interactions of species and populations
- Provide reliable estimates of distribution, abundance, and movement patterns of plant and animal populations
- Correlate species and population measures (e.g., demographics, distribution, abundance, movement patterns) with environmental conditions
- Determine status and trends, and assess population and species viability
- Assess wildlife and plant population responses to ecological experiments and management actions to provide feedback for adaptive management
- Identify multi-spatial and temporal factors affecting plant and animal species, including populations that migrate across international boundaries or reside outside North America

Goal 2: Evaluate natural and anthropogenic effects on the viability of plant and animal species and their habitats

- Advance the understanding of the effects of natural and anthropogenic factors on wildlife and plant distributions and abundance
- Advance the understanding of the effects of habitat changes on productivity, survival, and other factors influencing individual fitness in wildlife and plant populations
- Examine ecological and toxicological effects of individual and multiple stressors and non-chemical stressors (e.g., habitat degradation, invasive species, fire) on organisms, populations, and ecological communities
- Investigate the role of evolutionary and ecological processes in the decline of populations and species
- Identify and test possible indicator species or populations to monitor the effects of threats on species guilds, species at risk, and the general health of ecosystems
- Develop and evaluate means of minimizing threats, and develop strategies to monitor management and conservation efforts

Goal 3: Develop, assess, and apply state-of-the art tools for conservation and management of species and populations

- Use traditional (e.g., banding, telemetry) and emerging technologies (e.g., molecular markers and stable isotopes) to define species and assess population structure, status, distribution, and connectivity
- Apply genetic and molecular tools to assess population structure, status, distribution, connectivity in species and to evaluate effects from multiple stressors
- Develop scientific methods to determine sources, fate, exposure, and effects of environmental contaminants on species and populations
- Develop tools, models, and sampling designs for population estimates, trends, and risk assessments
- Develop and evaluate tools to assess the effects of invasive species on native species and populations

Goal 4: Provide a framework that will assist agencies and organizations in making complex decisions regarding conservation and sustainability of populations and species

- Synthesize biological and physical information to develop conceptual and statistical models of species and populations
- Facilitate use of scientific information and expertise in effective conservation and management of species at risk (e.g., recovery planning)

- Develop and test techniques for supporting conservation and recovery strategies, including technical expertise in risk analyses, population viability analyses, pedigree analyses, uncertainty analyses, and structured decision-making
- Conduct analyses to synthesize information on the evolutionary history, colonization patterns, species interactions, and genetic introgression in populations of plants and animals, particularly those at risk

Status and Trends

The Department of the Interior and other resource management agencies have an ongoing need for information on the status of the resources they manage. Even basic information about the distribution of special-status species is often lacking. More complex information needs involve assessing population viability, monitoring changes over time, assessing change relative to thresholds that trigger management actions, and adaptive management. Changes in species, habitats, and ecosystems are all of interest, and there is an increasing emphasis on the integration of monitoring efforts across scales and jurisdictions.

Inventory and monitoring studies sometimes have been considered separate from research, but FRESC considers such studies to be a type of research that involves questions about status and trends. Development of effective status and trends studies requires clear objectives as a starting point and active participation by personnel who will use the information. Scientists will work with resource managers to define objectives and design studies that will provide suitable information. They can help formulate objectives, identify state-of-the-art techniques that can be employed, or develop new approaches for gathering or analyzing appropriate information. Even more so than other types of research, status and trends studies are the most useful when they involve a close partnership between research and management.

The following goals and objectives will guide research and technology developments in status and trends for addressing resource management needs in the Pacific Northwest and the Intermountain West.

Goal 1: Understand status and trends and sustainability of ecosystem properties, ecological communities, and focal species groups

- For focal species, document and understand their distribution, abundance, and causes of trends
- Investigate and monitor effects of global climate change on terrestrial plant and animal communities
- Investigate and monitor condition and trends in aquatic, forest, and rangeland habitats
- Use long-term data to assess the impact of anthropogenic and ecological processes on habitats and species, but also develop a long-term monitoring strategy for key ecosystems
- Continue long-term monitoring projects in aquatic and terrestrial ecosystems and expand the scope of existing surveys to include other geographical areas and the suite of attributes monitored (e.g., emerging contaminants) in assessing effects on biological resources

Goal 2: Assist partner agencies in developing monitoring systems and programs that enable their management and stewardship of biological resources, and promote public understanding and appreciation

- Develop monitoring frameworks and sampling plans that facilitate integration of information from multiple spatial and temporal scales to track abundance, distribution, productivity and health of plants, animals, and ecosystems
- Develop protocols to monitor vital signs of ecosystem health
- Develop and evaluate inventory and monitoring methods, protocols, and technologies leading to more effective detection of trends
- Provide technical assistance to DOI bureaus in conceptualizing and developing monitoring programs
- Develop and evaluate national protocols for plant and animal status in aquatic, forest, and rangeland habitats
- Develop quantitative tools to monitor trends in distribution and abundance
- Collect, archive and share high-quality monitoring data in cooperation with our partners
- Develop and evaluate adaptive management programs

Goal 3: Coordinate and facilitate integration of inventory and monitoring across scales and jurisdictions

- Develop frameworks for multi-agency monitoring
- Pool data and synthesize findings from multiple studies to increase scientific knowledge across multiple scales and to provide information for informed decision-making
- Develop GIS applications to visualize and analyze spatial patterns in status and trends data